

Appl. No. : 10/698,878
Filed : October 31, 2003

REMARKS

Reconsideration and allowance of this application, as amended, is respectfully requested. Claims 1-13 were pending in this application prior to entry of the above-mentioned amendments. Claims 1, 3-9, 11 and 12 have been amended. New Claims 14-16 have been added. No new matter is added by these amendments.

Applicants submit that this application, as amended, is in condition for allowance and such action is earnestly requested. Each of the Examiner's reasons for rejection is addressed below.

Amendments to the claims

Claim 1 has been amended to clarify the invention. Claim 1, as amended, recites, *inter alia*, "applying an initial process current density, wherein the initial current density is lower than the transition current density; applying a first process current density to fill the cavity with the conductive material and form a substantially flat profile over the opening of the cavity, wherein the first process current density is substantially the same as the transition current density." This amendment is fully supported by the application as originally filed ("the Application") at, for example, paragraphs [0043] and [0052], and Claim 1 as originally filed.

Claims 3-8 have been amended to clarify the Claims' language.

Claim 9 has been amended to clarify the invention. Claim 9, as amended, recites, *inter alia*, "performing an electrodeposition process on a plurality of workpieces by depositing the conductive material onto the surface of the workpieces using a variable current density including an initial process current density, a first process current density to fill the cavity and form a substantially flat profile over the opening of the cavity, and a second process current density to form the substantially flat conductive layer over the cavity." This amendment is fully supported by the application at, for example, paragraphs [0043] and [0052], and Claim 9 as originally filed.

Claims 11 and 12 have been amended to match follow-on recitations with their proper antecedent in Claim 9.

New Claims 14-16 have been added. The new claims are fully supported by the application at, for example, Figures 13, 15 and 18, and Claims 11-13, as originally filed.

§112 and §132 rejections

The amendments set forth the March 6, 2006 response to the Office Action mailed on October 5, 2005 have been objected to under 35 U.S.C. §132(a) for introducing “new matter” into the disclosure. In particular, the Examiner has found that the disclosure does not provide clear support for various limitations added to independent Claims 1 and 9, namely applying an initial process current density to partially fill a cavity and a first process current density to fill the remainder of the cavity and form a substantially flat profile over the cavity. Additionally, the Examiner has rejected Claims 1-13 under 35 U.S.C. §112 as failing to comply with the written description requirement, asserting that the amended limitations of Claims 1 and 9 constitute new matter.

In view of the amendments to Claims 1 and 9, Applicants submit that the claims no longer introduce or constitute new matter, and respectfully request that these §112 and §132 rejections be withdrawn.

The Examiner has rejected Claims 3-7 under 35 U.S.C. §112 as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner asserts that there is insufficient antecedent basis for particular limitations in the claims, such as “third process current density,” as recited in original Claims 3-5 and 7; “a first pulsed process current density,” as recited in original Claim 6; and “a second pulsed process current density,” as recited in original Claim 7. The Examiner has further found that the claims “are in improper dependent form for failing to further limit the subject matter of a previous claim.”

First, Applicants note that the limitations referenced by the Examiner are not follow-on recitations to antecedents in Claim 1 or Claim 2. To illustrate this point, Claims 3, 6 and 7, as originally filed, recite, “applying *a* third process current density...”, “*a* first pulsed process current density” and “*a* second pulsed process current density,” respectively. Neither Claim 1 nor Claim 2 recites a third process current density, a first pulsed process current density, or a second pulsed process current density. Thus, the Examiner’s rejection on the basis of improper antecedent basis is improper.

Second, Applicants submit that amended Claims 3-7 are in proper dependent form because they limit the subject matter of claims from which they depend. To illustrate this point, amended Claim 3 recites “applying a third process current density before applying the first

Appl. No. : 10/698,878
Filed : October 31, 2003

process current density and after applying the initial process current density, wherein the third process current density is higher than the second process current density, and wherein the third process current density is applied for a third predetermined time that is shorter than the first predetermined time.” By reciting “a third process current density,” the scope of Claim 3 is narrowed with respect to the claim from which it depends (Claim 2). Similarly, Claims 4-7 introduce features that narrow the scope of the claims from which they depend. Consequently, Applicants respectfully request that the §112 rejection of Claims 3-7 be withdrawn.

§102 rejection

Claims 1-2 and 8-10 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,432,821 to Dubin et al. (“Dubin”). The Examiner asserts that Dubin teaches an electrodeposition process comprising the steps of determining the transition current density 706, applying an initial process current density 702 lower than the transition current density to partially fill a cavity with a conductive material, applying a first process current density 714 substantially the same as the transition current density to fill the remainder of the cavity (for holes having a size of 0.3-0.6 μm), and applying a second process current density 722 higher than the transition current density to form a substantially flat conductive layer. Additionally, the Examiner alleges that the electroplating method of Dubin yields a substantially flat profile over surface features since Dubin “reduces ‘die non-uniformity, measured as a reduction of hump step height over small features’.” See Final Office Action at page 5.

Applicants respectfully disagree with the Examiner. Initially, Applicants note that Dubin’s process taken as a whole reduces die non-uniformity. Applicants note that the Claims 1 and 9 do not merely recite overall flatness after the claimed sequence, but rather specify determining a single characteristic current density for achieving flatness, and use of that single density in a larger sequence of steps. In particular, Claims 1 and 9 first recite “determining a transition current density that is capable of filling ... and forming a substantially flat profile over an opening of the cavity,” followed by “applying a first process current density to fill the cavity ... and form a substantially flat profile over the opening ... wherein the first process current density is substantially the same as the transition current density ...”, as recited in Claim 1, and “performing an electrodeposition process ... using a variable current density including ... a first process current density to fill the cavity and form a substantially flat profile over the opening ...

Appl. No. : 10/698,878
Filed : October 31, 2003

wherein the first process current density is substantially the same as the transition current density,” as recited in Claim 9. These recitations relate to one of the applied densities, not to the sum product of multiple steps at different densities. Second, Claims 1 and 9 recite first process current density” in combination with two other (lower and higher) process current densities.

Applicants note that Dubin neither teaches nor suggests that any single current density, such as 706 (or 714 for that matter) has the characteristic that it would by itself yield a substantially flat profile over an opening of a cavity. Dubin merely teaches that, following an initiation forward current 702, a superfill operation with forward currents 704, 706 is used to fill the smallest damascene features. It is only the combined sequence of pulses (at multiple different current densities) that the Examiner points to as reducing in die non-uniformity.

Furthermore, Applicants submit that mere reduction in die non-uniformity is not tantamount to a “substantially flat profile,” as recited in Applicants’ Claims 1 and 9. To be clear, Dubin may reduce die non-uniformity without achieving a substantially flat profile over surface features.

Consequently, as Dubin does not teach or include the limitations of Claims 1 and 9, Applicants respectfully request that the §102 rejection of Claims 1 and 9 be withdrawn.

Claims 2, 8 and 10 depend from and therefore include all of the limitations of Claims 1 and 9, in addition to reciting particular features of advantage and utility. Dubin neither teaches nor suggests the limitations of Claims 1 and 9, let alone the unique combination of limitations of Claims 2, 8 and 10. Accordingly, Applicants respectfully request that the §102 rejection of Claims 2, 8 and 10 also be withdrawn.

§103 rejections and related findings

Claims 3-7 and 11-13 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Dubin. Without acquiescing in the Examiner’s reasons for rejection, Applicants submit that Claims 3-7 and 11-13 are allowable because they depend from and therefore include all of the limitations of Claims 1 and 9, in addition to reciting features of particular advantage and utility. Dubin neither teaches nor suggests the limitations of Claims 1 and 9, let alone the unique combination of limitations of Claims 3-7 and 11-13. In view of the asserted allowability of Claims 1 and 9, as discussed above, Applicants respectfully request that the §103 rejection of Claims 3-7 and 11-13 be withdrawn.

Appl. No. : 10/698,878
Filed : October 31, 2003

In responding to arguments presented in the March 6, 2006 amendment, the Examiner has found that Dubin teaches that “the superfill and reverse plating steps can be repeated a number of times prior to the bulk fill operation in order to provide the desired surface morphology for chemical mechanical polishing (CMP).” The Examiner alleges that, in doing so, Dubin addresses problems associated with CMP of surfaces with uneven surface morphologies. Additionally, the Examiner asserts that, assuming the surface of Dubin does not have a substantially flat profile, it would have been obvious for the skilled artisan to modify Dubin by optimizing various combinations of current densities and durations to produce a substantially flat profile, because it would reduce defects (dishing and erosion) caused by overpolishing of the plated features during chemical mechanical polishing (CMP).

Although the Examiner has not formally issued an obviousness rejection of the independent claims in view of the argument presented above, Applicants will respond to the Examiner’s argument.

Initially, Applicants note that the Examiner’s counterargument (*i.e.*, “Even assuming the surface of Dubin et al. does not have a substantially flat profile...”) is indicative of the Examiner’s ambivalence with respect to Dubin providing a process that achieves a substantially flat profile, for if the process of Dubin did in fact provide a substantially flat provide, there would be no need for the counterargument.

Applicants reiterate that Dubin’s process as a whole is geared toward reducing in die non-uniformity. In contrast, Applicants describe a substantially flat profile over an opening of a cavity as characterizing a single process current density (Applicants are not suggesting that a reduction in die non-uniformity is equivalent to achieving a substantially flat profile over an opening of a cavity, but that is irrelevant to the distinction). The skilled artisan would not have been motivated to optimize Dubin because, aside from the hindsight benefit of Applicants’ invention, which is forbidden (see, *e.g.*, *In re Gorman* and *In re Rouffet*), there is no teaching or suggestion in Dubin that process current density 714, which the Examiner has equated with Applicants’ transition current density (see above), would by itself fill a cavity and achieve a substantially flat profile over an opening of the cavity. Even accepting the Examiner’s assumptions, at most this suggests optimizing the combined result of all three current densities 702, 714 and 722. Moreover, Dubin already claims to solve the dishing and erosion problem, eliminating any motivation the skilled

Appl. No. : 10/698,878
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artisan would have for further modification (*i.e.*, without a problem, the skilled artisan would have no motivation to optimize Dubin).

Further, aside from the hindsight there is no motivation to optimize Dubin's process conditions to achieve a substantially flat profile. Further, there is no evidence that Dubin's process could or would have been expected to be optimizable to achieve a substantially flat profile, and the skilled artisan would not have modified Dubin without any expectation of success. Applicants' invention, in contrast, operates differently and can achieve a substantially flat profile.

CONCLUSION

In view of the foregoing amendments and remarks, Applicants respectfully submit that this application is in condition for allowance and request the same. If there is any further hindrance to allowance of the pending claims, the Examiner is invited to contact the undersigned.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: _____

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By: _____

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